



Informe de ensayo nº:
Test report No:

NIE: 45355REM.006A3

Test Report (Modification 3)

FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-13 Edition);
ICES-003 ISSUE 5 (2012)

| | |
|---|---|
| Identification of item tested.....: | Wireless sensor node for the Internet of Things |
| Trademark | Libelium |
| Model and /or type reference | Wasmote Plug & Sense! 900 US |
| Other identification of the product | S/N: Prototype |
| Final HW version | 1.0 |
| Final SW version | 1.0 |
| FCC ID | XKM-WPS-900-V1 |
| IC | 8472A-WPS900V1 |
| Features | Can transmit with private RF protocol in the 900 MHz ISM band. Contains an XBee-PRO 900HP radio. |
| Manufacturer | LIBELIUM COMUNICACIONES DISTRIBUIDAS, S.L. C/ Escatrón, 16. (Edificio Libelium), C.P.: 50014 Zaragoza. Spain. |
| Test method requested, standard.....: | FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-13 Edition); ICES-003 ISSUE 5 (2012) |
| Summary | IN COMPLIANCE |
| Approved by (name / position & signature).....: | Francisco Cañas Regulatory Lab Director |
| Date of issue.....: | 2016-11-10 |
| Report template No.....: | FDT11_18 |

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Competences and guarantees

AT4 wireless is a testing laboratory accredited by the National Accreditation Body (ENAC -Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

In order to assure the traceability to other national and international laboratories, AT4 wireless has a calibration and maintenance program for its measurement equipment.

AT4 wireless guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at AT4 wireless at the time of performance of the test.

AT4 wireless is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of AT4 wireless.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of AT4 wireless and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the AT4 wireless internal document PODT000.

Usage of samples

Samples under test have been selected by: the Client.

Sample S/01 is composed of the following elements:

| Control N° | Description | Model | Serial number | Reception date |
|------------|--|----------------|---------------|----------------|
| 45355/009 | Sensor node with wireless communications | Plug&Sense | 9 | 2015-12-03 |
| 45355/045 | Connector for 3.3 – 4.2Vdc battery connector | Plug&Sense | --- | 2015-12-03 |
| 45355/048 | 900MHz RF antenna | Plug&Sense | --- | 2015-12-03 |
| 45355/073 | Luminosity probe | Plug&Sense | --- | 2015-12-03 |
| 45355/133 | Module | XBee-PRO 900HP | --- | 2015-12-03 |

Modifications realized on sample S/01:

Sample S/01 incorporates two ferrites with the code MURATA BLM21AG601SN1, one in the clock input and the other in the clock output. It was added a 50nF capacitor to the DC/DC input. It was added a 50nF capacitor to the DC/DC output. It was added a toroidal ferrite with the code WÜRTH 7427013 with two turns on the mains cable. It was diminished the charge current with R43 to 3,3K. It was added a ferrite with the code WÜRTH 742 712 22 with two turns in the power supply cable. It was added a ferrite with the code WÜRTH7427503 in the positive load cable and it was modified the C15 value to 22µF.

Auxiliary PC for Operation Mode 02: Dell Latitude E6440 (CTC-1230-D)

Test sample description

This device receives data from sensors and sends information with its wireless radio. It is battery powered and can be easily programmed.

Identification of the client

LIBELIUM COMUNICACIONES DISTRIBUIDAS, S.L.

C/ Escatrón, 16. (Edificio Libelium), C.P.: 50014
Zaragoza. Spain.

Testing period

The performed test started on 2015-11-04 and finished on 2015-11-05

The tests have been performed at AT4 wireless.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

| | |
|--------------------------------------|------------------------------|
| Temperature | Min. = 15 °C Max. = 35 °C |
| Relative humidity | Min. = 20 % Max. = 80 % |
| Shielding effectiveness | > 100 dB |
| Reference resistance to earth | < 1 Ω |

In the semianechoic chamber, the following limits were not exceeded during the test.

| | |
|--------------------------------------|--|
| Temperature | Min. = 15 °C Max. = 30 °C |
| Relative humidity | Min. = 45 % Max. = 60 % |
| Air pressure | Min. = 860 mbar Max. = 1060 mbar |
| Shielding effectiveness | > 100 dB |
| Reference resistance to earth | < 1 Ω |
| Normal site attenuation (NSA) | < ± 4 dB at 10 m distance between item under test and receiver antenna, (30 MHz to 1000 MHz) |
| Site VSWR | < ± 6 dB at 3m distance between item under test and receiver antenna, (1 GHz to 18 GHz) |
| Field homogeneity | More than 75% of illuminated surface is between 0 and 6 dB (26 MHz to 18 GHz). |

In the chamber for conducted measurements, the following limits were not exceeded during the test:

| | |
|--------------------------------------|-------------------------------------|
| Temperature | Min. = 15 °C Max. = 30 °C |
| Relative humidity | Min. = 45 % Max. = 60 % |
| Air pressure | Min. = 860 mbar Max. = 1060 mbar |
| Shielding effectiveness | > 100 dB |
| Reference resistance to earth | < 1 Ω |

Modifications to the reference test report

The following modifications in respect to the test report number 45355REM.006 were included in the next clauses and sub-clauses:

- By client requirement it was modified the IC field of the page 1.
- The Operation Mode 02 defined as “programming mode connected by USB cable to an auxiliary PC” is included in the report. The measurement results for this mode are added.

This modification test report cancels and replaces the test report 45355REM.006, 45355REM.006A1 and 45355REM.006A2 .

Remarks and comments

The tests have been performed by the technical personnel: Pedro Manuel Valenzuela & José Manuel Márquez.

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 30 MHz to 1000 MHz is $I = \pm 4,37$ dB for quasi-peak measurements, $I = \pm 4,28$ dB for peak measurements ($k = 2$).

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 1000 MHz to 26GHz is $I = \pm 2,62$ dB for peaks and average measurements ($k = 2$).

Testing verdicts (Legend)

| | |
|-----------------------------|-----|
| Not applicable | N/A |
| Pass | P |
| Fail | F |
| Not measured | N/M |

| List of equipment used during the test | | | | | |
|--|--------------------------------|---------------------------------|--------------|------------------|------------------|
| CONTROL NUMBER | DESCRIPTION | MANUFACTURER | MODEL | LAST CALIBRATION | NEXT CALIBRATION |
| 1999 | EMI Receptor | ROHDE & SCHWARZ | ESIB 26 | 2015-06-16 | 2017-06-16 |
| 2932 | Bilog Hybrid Antenna | SUNOL | JB6 | 2014-05-11 | 2017-05-11 |
| 4612 | Horn Antenna | SCHWARZBECK MESS- ELEKTRONIK | BBHA 9120D | 2013-12-29 | 2016-12-29 |
| 4658 | RF Amplifier | SCHWARZBECK | BBV9743 | 2015-03-19 | 2016-03-19 |
| 4662 | Transient limiter | SCHWARZBECK | VTSD 9561-D | 2014-02-12 | 2016-02-12 |
| 4659 | RF Amplifier | SCHWARZBECK | BBV 9718 | 2015-09-29 | 2016-09-29 |
| 4729 | RF Amplifier | BONN ELEKTRONIK | BLMA 1840-1M | 2015-12-02 | 2017-12-02 |
| 3545 | Temperature and humidity probe | PICO TECHNOLOGY | HUMIDIPROBE | 2015-03-04 | 2016-03-04 |
| 3556 | Digital termohigrometer | T&D | TR-72W | 2015-04-16 | 2016-04-16 |
| 4657 | Horn Antenna | SCHWARZBECK | BBHA 9170 | 2014-03-28 | 2017-03-28 |
| 0224 | Artificial network | ROHDE & SCHWARZ | ESH2-Z5 | 2015-02-06 | 2017-02-06 |

Appendix A – Test result

CONTENT

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DESCRIPTION OF THE OPERATION MODES

The operation modes described in this paragraph constitute a functionality of the sample under test for itself. Every operation mode takes a failure criteria for the immunity test that they were applying to it and a monitoring to guarantee performance of the same ones.

The operation modes used by the samples to which the present report refers, are shown in the following table:

| OPERATION MODE | DESCRIPTION |
|----------------|---|
| OM#01 | EUT ON. Equipment in Idle mode. Charging battery: 6Vdc. |
| OM#02 | EUT ON. Equipment in programming mode connected by USB cable to an auxiliary PC. Charging battery: 6Vdc. PC power supply: 115Vac. |

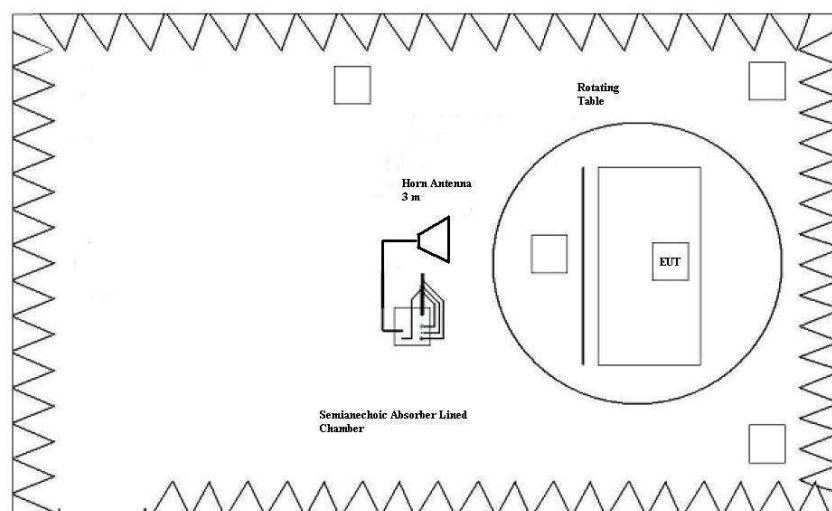
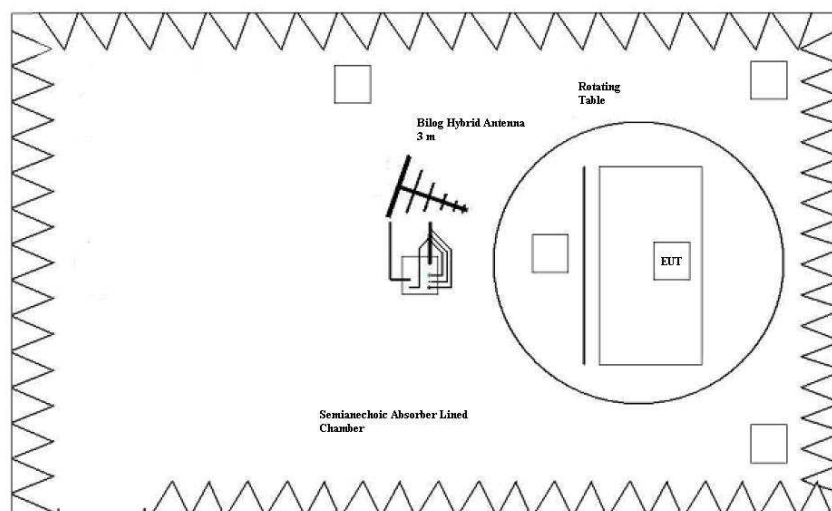
RADIATED EMISSION. ELECTROMAGNETIC FIELD MEASURE

| | | |
|----------------|--------------------------|---|
| LIMITS: | Product standard: | FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 Edition); ICES-003 ISSUE 5 (2012) |
| | Test standard: | FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 Edition); ICES-003 ISSUE 5 (2012) |

Limits of interference Class B

The applied limit for radiated emissions, 3 m distance, according with the requirements of FCC Rules and Regulations 47 CFR Part 15.109, Subpart B (10-01-13 Edition); ICES-003 ISSUE 5 (2012) & ANSI C63.4-2009 in the frequency range 30 MHz to 26 GHz, for Class B equipment, which is a transmitter in a band over 500 MHz, was:

| Frequency range (MHz) | QP Limit for 3 m ($\mu\text{V/m}$) | QP Limit for 3 m ($\text{dB}\mu\text{V/m}$) |
|-----------------------|--------------------------------------|---|
| 30 to 88 | 100 | 40 |
| 88 to 216 | 150 | 43.52 |
| 216 to 960 | 200 | 46.02 |
| Above 960 | 500 | 53.98 |
| Above 1000 | Limit for 3m AVG | Limit for 3m PK |
| | 53.98 $\text{dB}\mu\text{V/m}$ | 73.98 $\text{dB}\mu\text{V/m}$ |



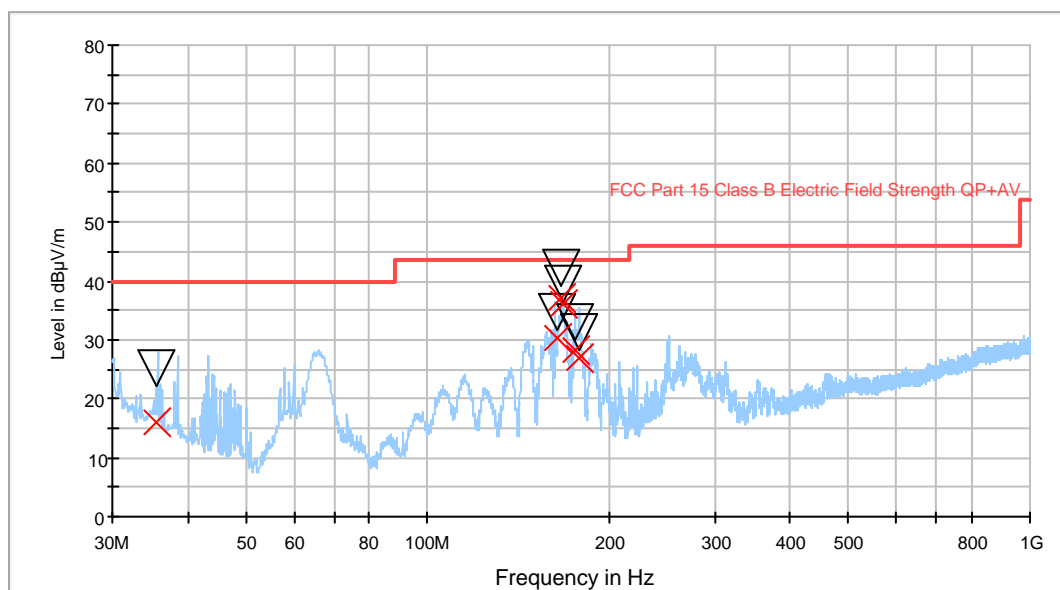
| | |
|--------------------------------|--|
| TESTED SAMPLES: | S/01 |
| TESTED OPERATION MODES: | OM#01 & OM#02 |
| TEST RESULTS: | CRmmnn: CR, Radiation Condition; mm: Sample number; nn: Operation mode |

| CRmmnn | Description | Result |
|---------------|--|--------|
| CR0101RB | Range: 30 MHz - 1000 MHz. | P |
| CR0101RA_1_PH | Range: 1 GHz - 18 GHz. Horizontal polarization. | P |
| CR0101RA_1_PV | Range: 1 GHz - 18 GHz. Vertical polarization. | P |
| CR0101RA_2_PH | Range: 18 GHz - 26 GHz. Horizontal polarization. | P |
| CR0101RA_2_PV | Range: 18 GHz - 26 GHz. Vertical polarization. | P |
| CR0102 | The programming USB mode (02) is previewed and compared with normal mode (01). It is checked that the normal operation mode is the worst case, so the final measurements are performed on operation mode 01. | P |

Radiated Emission. CR0101RB

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc

FCC class B



▽ FCC Part 15 Class B Electric Field Strength QP+AV MaxPeak
— Preview Result 1-PK+ QuasiPeak

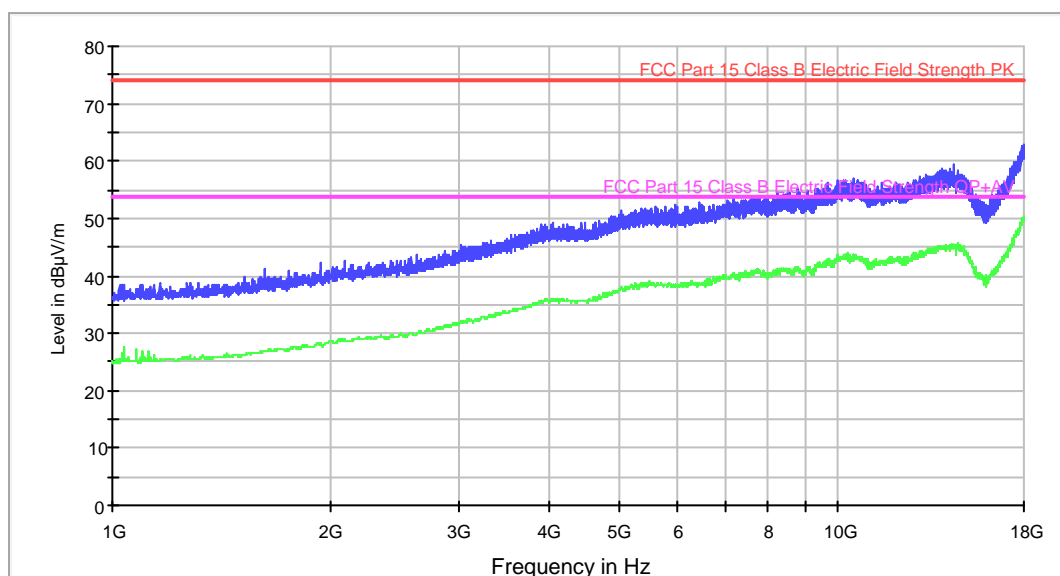
Maximizations

| Frequency (MHz) | MaxPeak (dBµV/m) | QuasiPeak (dBµV/m) | Height (cm) | Polarization | Azimuth (deg) |
|-----------------|------------------|--------------------|-------------|--------------|---------------|
| 35.514629 | 25.3 | 16.1 | 100.0 | V | 45.0 |
| 163.665731 | 34.6 | 30.1 | 174.0 | H | 61.0 |
| 166.567134 | 42.1 | 37.1 | 165.0 | H | 62.0 |
| 167.450701 | 39.3 | 36.0 | 144.0 | H | 241.0 |
| 175.874950 | 32.9 | 28.3 | 130.0 | H | 81.0 |
| 179.141082 | 31.5 | 26.9 | 134.0 | H | 81.0 |

Radiated Emission. CR0101RA_1_PH

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc. Horizontal Polarization.

FCC 1-18GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

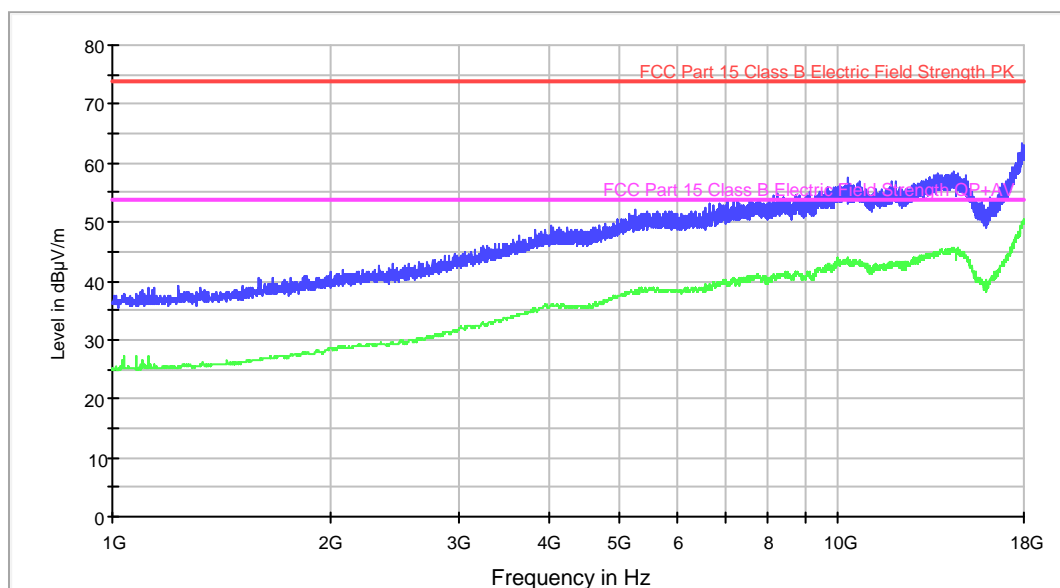
Subrange Maxima

| Frequency (MHz) | MaxPeak-ClearWrite (dBµV/m) | Average-ClearWrite (dBµV/m) |
|-----------------|-----------------------------|-----------------------------|
| 1162.000000 | 38.8 | 25.3 |
| 1623.000000 | 41.1 | 26.8 |
| 2090.000000 | 42.5 | 28.7 |
| 3028.000000 | 45.3 | 32.1 |
| 4053.000000 | 49.2 | 35.8 |
| 5609.000000 | 51.9 | 38.5 |
| 7172.000000 | 53.6 | 40.4 |
| 9977.000000 | 56.5 | 43.7 |
| 13174.000000 | 57.7 | 44.5 |
| 17978.000000 | 63.0 | 50.2 |

Radiated Emission. CR0101RA_1_PV

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc. Vertical Polarization.

FCC 1-18GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

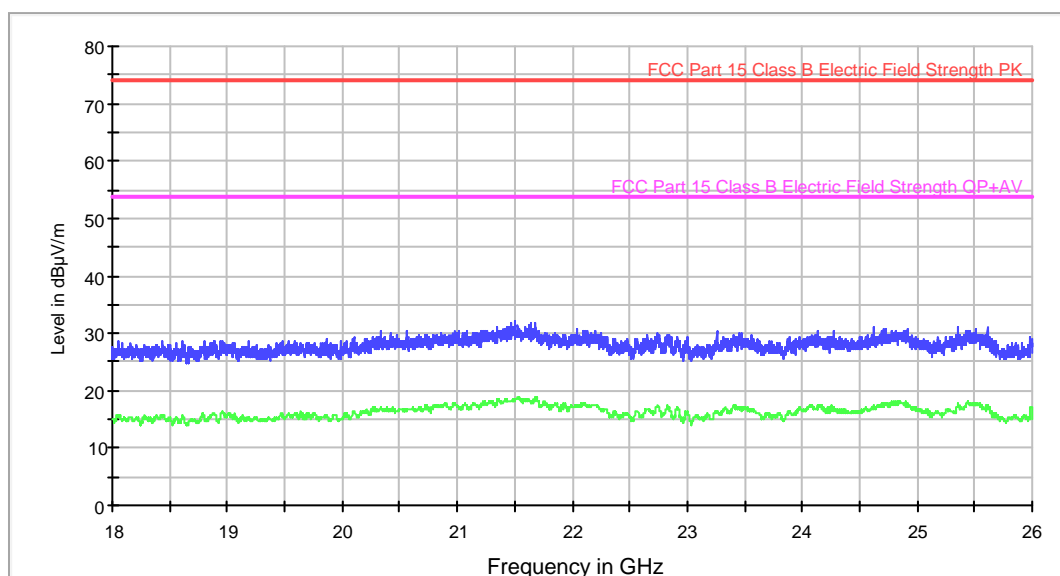
Subrange Maxima

| Frequency (MHz) | MaxPeak-ClearWrite (dBµV/m) | Average-ClearWrite (dBµV/m) |
|-----------------|-----------------------------|-----------------------------|
| 1233.000000 | 39.0 | 25.4 |
| 1665.000000 | 40.6 | 27.0 |
| 2330.000000 | 42.5 | 29.3 |
| 3160.000000 | 45.3 | 32.4 |
| 4012.000000 | 49.2 | 35.8 |
| 5263.000000 | 52.0 | 38.5 |
| 7245.000000 | 53.6 | 40.1 |
| 10062.000000 | 56.3 | 43.2 |
| 10267.000000 | 57.5 | 43.6 |
| 17906.000000 | 63.5 | 49.9 |

Radiated Emission. CR0101RA_2_PH

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc. Horizontal Polarization.

FCC 18-26GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

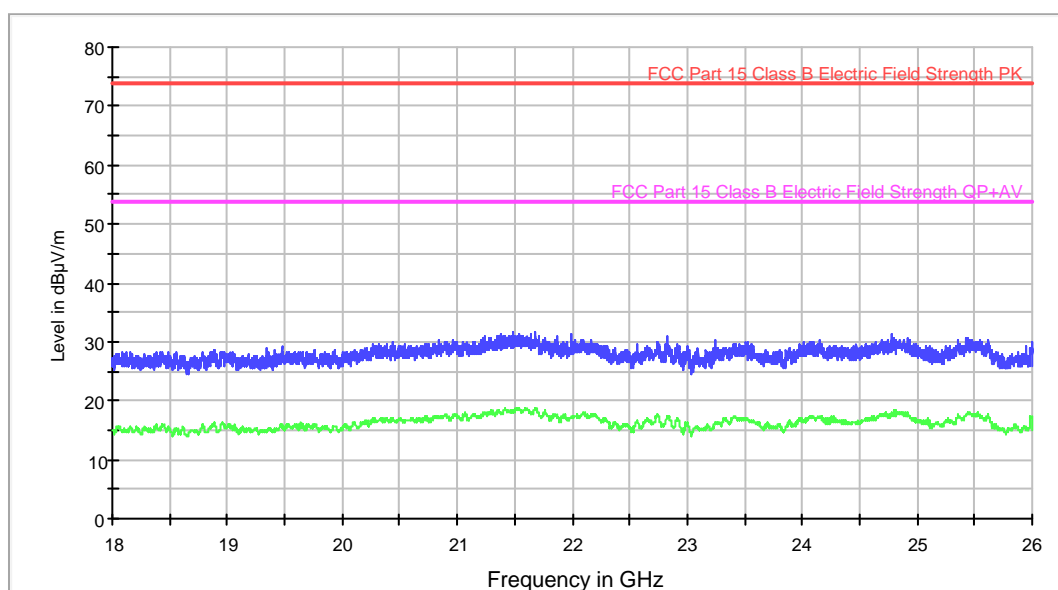
Subrange Maxima

| Frequency (MHz) | MaxPeak-ClearWrite (dBµV/m) | Average-ClearWrite (dBµV/m) |
|-----------------|-----------------------------|-----------------------------|
| 18608.000000 | 28.8 | 15.4 |
| 18966.000000 | 28.7 | 16.1 |
| 20097.000000 | 29.0 | 16.5 |
| 20329.000000 | 30.3 | 16.9 |
| 21503.000000 | 32.0 | 18.2 |
| 21682.000000 | 31.7 | 18.4 |
| 23255.000000 | 30.5 | 16.5 |
| 24136.000000 | 30.5 | 17.2 |
| 24617.000000 | 31.0 | 17.1 |
| 25353.000000 | 31.1 | 17.4 |

Radiated Emission. CR0101RA_2_PV

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc. Vertical Polarization.

FCC 18-26GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

Subrange Maxima

| Frequency (MHz) | MaxPeak-ClearWrite (dBµV/m) | Average-ClearWrite (dBµV/m) |
|-----------------|-----------------------------|-----------------------------|
| 18162.000000 | 28.3 | 15.5 |
| 19347.000000 | 28.9 | 15.0 |
| 19473.000000 | 29.3 | 16.1 |
| 20840.000000 | 30.4 | 17.4 |
| 21483.000000 | 31.5 | 18.2 |
| 21674.000000 | 31.7 | 18.5 |
| 22833.000000 | 31.0 | 17.2 |
| 24146.000000 | 30.3 | 17.3 |
| 24785.000000 | 31.2 | 17.5 |
| 25442.000000 | 30.6 | 17.9 |

CONTINUOUS CONDUCTED EMISSION

| | | |
|----------------|--------------------|---|
| LIMITS: | Product standard : | FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 Edition); ICES-003 ISSUE 5 (2012) |
| | Test standard : | FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 Edition); ICES-003 ISSUE 5 (2012) |

CLASS B

The applied limit for continuous conducted emissions in power leads, according with the requirements of FCC Rules and Regulations 47 CFR Part 15, Subpart B (10-01-13 Edition), Secs. 15.107, 15.109 and Subpart C (10-1-13 Edition) Secs. 15.207 & ICES-003 Issue 5 (2012), in the frequency range 0,15 to 30 MHz, for Class B equipment was:

| Frequency range (MHz) | Limit (dB μ V) | |
|--------------------------|--------------------|---------|
| | Quasi-peak | Average |
| 0,15 to 0,5 | 66-56 | 56-46 |
| 0,5 to 5 | 56 | 46 |
| 5 to 30 | 60 | 50 |

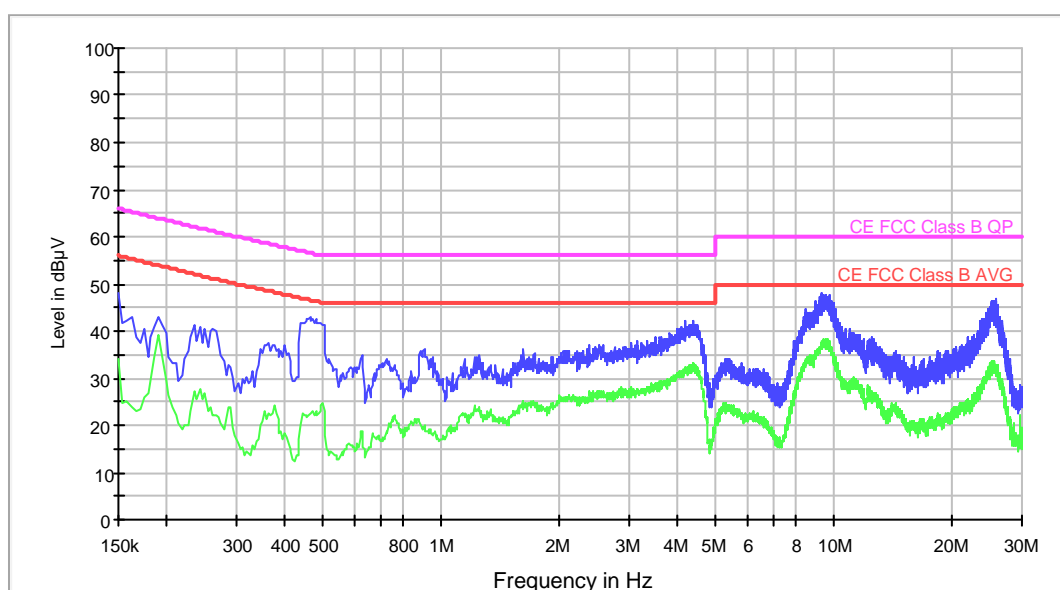
| | |
|--------------------------------|--|
| TESTED SAMPLES: | S/01 |
| TESTED OPERATION MODES: | OM#02 |
| TEST RESULTS : | CCmmnnhh: CC, Conducted Condition; mm: Sample number; nn: Operation mode; hh: wire |

| CCmmnnhh | Description | Result |
|----------|---------------------|--------|
| CC01020N | Neutral wire noise. | P |
| CC0102L1 | Phase wire noise. | P |

Conducted Emission. CC01020N

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#02
Description: EUT ON. Equipment in programming mode connected by USB cable to an auxiliary PC. Charging battery: 6Vdc. PC power supply: 115Vac. Neutral wire noise.

EC FCC Class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— CE FCC Class B AVG — CE FCC Class B QP

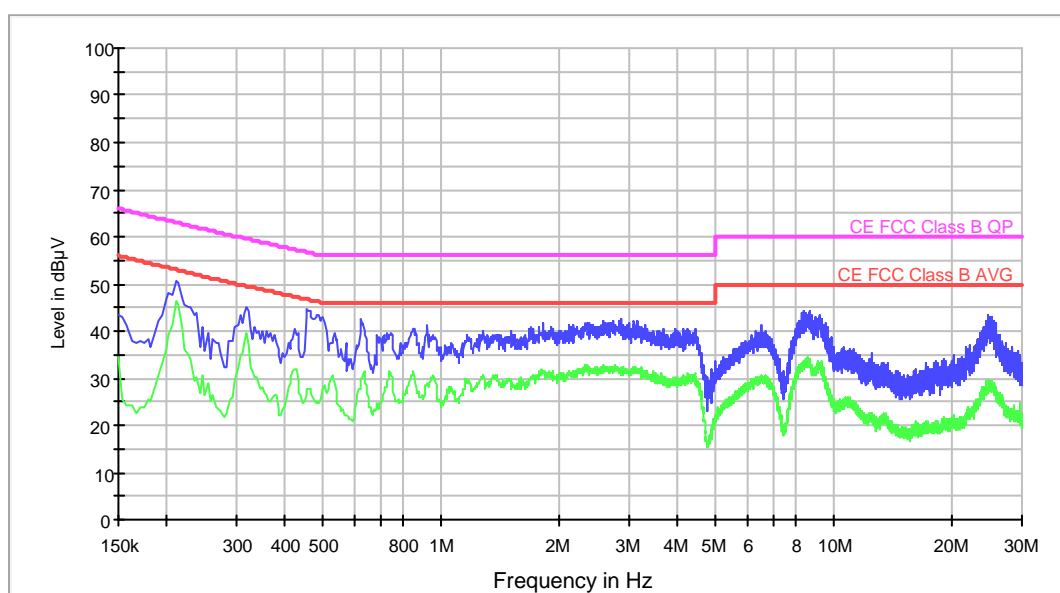
Subrange Maxima

| Frequency (MHz) | MaxPeak-ClearWrite (dBµV) | Average-ClearWrite (dBµV) |
|-----------------|---------------------------|---------------------------|
| 0.150000 | 48.0 | 33.9 |
| 0.262000 | 40.3 | 22.0 |
| 0.462000 | 43.0 | 22.4 |
| 0.902000 | 36.3 | 20.2 |
| 1.618000 | 36.3 | 24.0 |
| 3.598000 | 38.7 | 29.2 |
| 4.390000 | 42.1 | 32.0 |
| 9.282000 | 48.0 | 36.9 |
| 10.434000 | 41.0 | 28.9 |
| 25.826000 | 46.9 | 31.5 |

Conducted Emission. CC0102L1

Project: 45355REM.006
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/01
Operation mode: OM#02
Description: EUT ON. Equipment in programming mode connected by USB cable to an auxiliary PC. Charging battery: 6Vdc. PC power supply: 115Vac. Phase wire noise.

EC FCC Class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— CE FCC Class B AVG — CE FCC Class B QP

Subrange Maxima

| Frequency (MHz) | MaxPeak-ClearWrite (dBμV) | Average-ClearWrite (dBμV) |
|-----------------|---------------------------|---------------------------|
| 0.210000 | 50.5 | 46.4 |
| 0.318000 | 45.0 | 39.7 |
| 0.454000 | 44.9 | 27.8 |
| 0.918000 | 41.1 | 28.8 |
| 1.806000 | 41.5 | 31.4 |
| 2.866000 | 42.4 | 31.5 |
| 4.430000 | 40.5 | 29.9 |
| 8.370000 | 44.1 | 33.0 |
| 10.558000 | 36.7 | 25.0 |
| 24.658000 | 43.3 | 29.0 |